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ORIGINAL PAPER

Heritage trees and landscape design in urban areas of Rwanda

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Abstract: Trees play a key role in neighborhood landscapes, a belief that has been widely held for millennia in areas beyond Sub-Saharan Africa. Unfortunately, awareness of modern landscape architecture was almost absent in Rwanda until the late 20th century. Today, houses with surrounding decorative and amenity plants are a common feature in Rwanda's neighborhood landscapes and, as the villagization of settlements progresses, new kinds of landscapes are emerging. This paper explores neighborhood tree planting around human settlements in the country. Remote sensing, photogrammetry, photo interpretation, and plant surveys were the core methods used. The average tree cover fraction ranged between 10%–35%. As the result of what is hereafter referred to as the "luxury effect," a discrete gradient was detected along which the diversity of ornamental and amenity trees increases with the socio-economic status of neighborhoods: from rural settlements to urban residences via a series of intermediate designs, in which different levels of human-built vegetated areas alternate with non-landscaped spaces. Showy, non-productive amenity trees tend to occur more in wealthy quarters of the inner core of cities while edible ornamentals and other productive neighborhood trees prevail in rural and spontaneous settlements. In general, the practice of landscape plant design, in spite of its constant improvement, is still striving to get established as a profession in the country.

Keywords: heritage trees; patterns; settlement neighborhoods, Rwanda

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Introduction

A standing stock of different types of trees in residential neighborhoods, whether deliberately cultivated or allowed to grow naturally, has been recognized as necessary (Fao 1985). This kind of belief that trees play a key role in neighborhood landscapes has been widely held for millennia in areas beyond Sub-Saharan Africa. For instance, when Alexander the Great defeated the Persians and reached India in the 5th century (Janick 2007). Later, the Mughal emperors (1526-1858 AD) introduced to India the famous Chinar tree (Platanus orientalis) for neighborhood beautification (Prakash 2010). Despite the fact that the widely open nature of the fields made cultivation easy across in Rwanda, poor soil and limited rain made intensive farming almost impossible at least until the dawn of the 20th century. Modern techniques of crop breeding, soil fertilization, and agricultural irrigation were yet to be embraced in the country. In response long-fallow shifting cultivation was adopted, which kept populations sparse, settlements scattered, housing rudimentary and professional gardening almost absent. Under such conditions, communities generally had to rely on the natural landscape, which was abundant and easily accessible at that time, and could enjoy the wealth of plants without gardening. As a result, awareness of neighborhood plant planning, inherent to urban design and modern landscape practice, was almost nonexistent in Rwanda at least until the dawn of the 20th century.

However, since the late 1990s, the country has undertaken a settlement policy of grouping people in villages in contrast to the traditional habitat in which countryside homesteads are scattered on the hills' slopes. Furthermore, the country envisions developing basic infrastructure in urban centers and other development poles, enabling the decongestion of agricultural zones, with the proportion of those living in towns and cities expected to increase to 30% by 2020 (Minecofin 2000). Today, although the majority of Rwandans still live in scattered settlements, an increasing number of people already live in cluster villages. Houses with surrounding neighborhood tree communities are a very common feature in the country and, as the villagization of settlements

progresses, new kinds of landscapes are emerging with their associated scenic beauty. This work attempts to explore aspects of land cover and patterns of plant assemblages around settlement neighborhoods in the country.

Materials and methods

Study site

The study was conducted in Rwanda, a small landlocked country in Central-Eastern Africa, located at 2º00 south of the Equator and 30º00 east of the Greenwich Meridian Line. The country's average elevation is 1,250 m, with the lowest point lying within the Rusizi valley at 950 m and the highest point situated at the summit of mount Karisimbi at 4,519 m. Four different seasons are present: two short rainy/dry seasons, and two long rainy/dry seasons. Annual rainfall averages 80 cm (Department of State 2011). Unlike eastern savanna districts, some regions in the western and northwestern mountains receive more than 1,500 mm per year, with heavy downpours occurring almost daily during the two rainy seasons (Mininfra 2007). The temperature varies with both elevation and land topography, with an average of 20–22°C at 1,545 m in Kigali city.

The land use profile included 45.56% of arable land, 10.25% of permanent crops and 44.19% of other types of land cover, including settlements and road networks (Fao, 2005). In particular, both city area of Kigali and the population have grown by more than 600% in just a decade and a half; that is, from 1991 to 2006 (Fig.1).

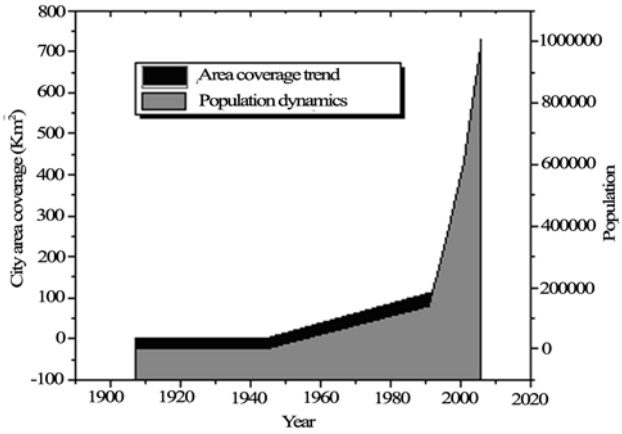

Fig.1 Population growth and area expansion in Kigali city [Adapted from Sano, 2007]

Using records from 1960 to 2002, Fig. 2 illustrates the evolution of forest plantation area in Rwanda (including urban forests), quite in parallel with the city area expansion and population growth rates as exposed in Fig.1 above.

Today, although the majority of Rwandans still live in scattered settlements, an increasing number of people already live either in urban areas or cluster villages. As a result, neighborhoods with surrounding amenity plant communities are a very common feature in the country and new kinds of landscapes have emerged with their associated scenic beauty.

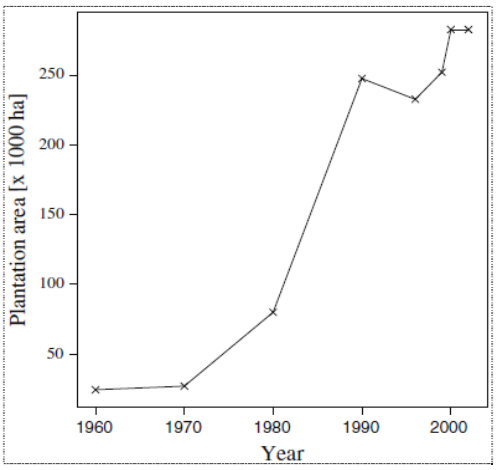

Fig. 2 Evolution of forest plantation area in Rwanda [Ndayambaje & Mohren, 2011]

Data acquisition

Desk-Based Study

Cultural and historical data were retrieved from a desk-based study, during which a collation of available data on pre-colonial flora records and indigenous architectural techniques was carried out in order to derive relevant information on plant landscape planning and design in Rwanda's early settlements. Libraries at the National University of Rwanda and National Institute for Scientific and Technological Research were visited. Corroborative evidence was gathered from national museums as well as from a series of interviews with gardeners and green space managers from three randomly selected urban districts: Gasabo, Ngoma, and Rubavu.

Vegetation survey

A field assessment of tree cover and plant landscape patterns in Rwanda's contemporary settlement neighborhoods was carried out. Each study site was stratified into homogenous zones based on green space layout and natural characteristics (Elzinga et al. 2001). The resulting green space zones and patches were surveyed within randomly selected sampling units, consisting of 2 × 2 km grid squares on the respective city maps. A tree population survey was carried out, first by selecting a point at the center of each of the sampling units, from which the nearest residential property was sampled as well as any street tree stand, institutional garden, or forest cover, provided that it occurred within 500 m of the center-point (Jaenson et al. 1992; Smith 2006; Stewart 2009). In total, 82.425 km^2 were surveyed, amounting to roughly 5% of the total urban area coverage in Rwanda.

Image analysis

To retrieve ancillary data, which were to help extrapolate results from the ground-based tree survey to the entire urban system, remotely-acquired imagery data were collected through virtual tours with Google Earth viewer. Prior to photogrammetric analy-

sis, images pertaining to each of the survey sites were enhanced and supervisedlyclassified into two land-use categories, namely built and vegetative land cover (Hope et al. 2003; Thomas et al. 2008). Post-classification formats were then converted into numerical maps to allow the extraction of image metrics.

The fraction of green space cover ($F_{GSC}=X/N$) was deduced by solving a 2-unknown equation relating the number of pixels to the mean pixel value[Adapted from Seburanga 2011]:

$$\begin{array}{l|ll} P_1X+P_2Y=MN & 1 & F_{TC}=X/N \\ X+Y=N & -P_2 & =(M-P_2)/(P_1-P_2) \\ \hline (P_1-P_2)X=(M-P_2)N & & \%\,\mathrm{cover}=100F_{TC} \end{array}$$

where P1 and P2 are pixel values for respective colors: X and Y, pixel counts for respective colors: M, the mean pixel value and N, the total number of pixels in the image or the total number of box counts.

To validate the above model, the resulting green cover was compared not only with the corresponding threshold of vegetation index (NDVI), but also with estimates from the ground-truth data (Carfagna & Gallego 2005; Folega et al. 2011.).

Results

Fraction of tree cover in settlement neighborhoods

Trees, dotted across rural landscapes, around houses, along field boundaries, and street verges were common features around the area of study.

Trees properly placed around buildings not only played a decorative role but also served as energy stocks, windbreaks, and shade providers. For the majority of the population living in cluster villages away from the immediate vicinity of forested lands, trees in the neighborhood had an even more significant role, which is depicted in the observed difference in tree fraction cover between the two settlement systems (Fig.3).

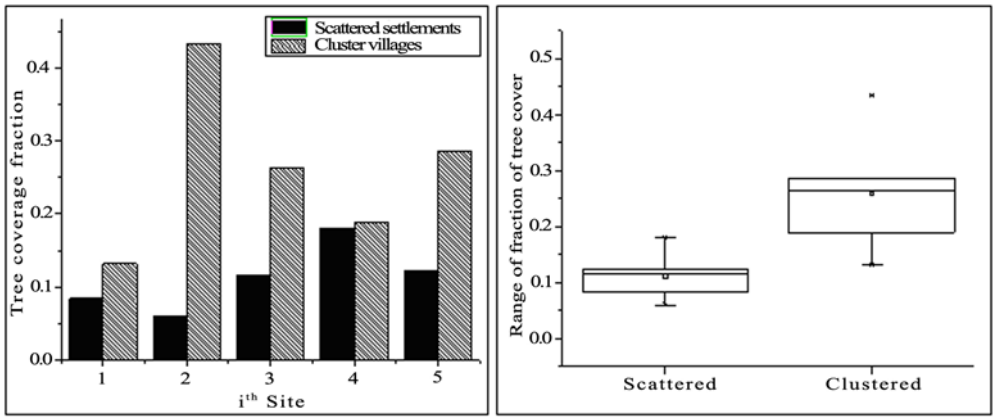

Fig. 3 Comparison of fraction of tree cover between settlement systems

A one-way ANOVA test showed a significant difference between the mean values of the two distributions ($F_{1,9}=7.231$, $\alpha < 0.05$), supporting the idea that tree planting around neighborhoods has something to do with settlement type. In general, it appeared that, although still poorly documented, the role trees play outside established forested areas and reserves of Rwanda is critical.

A gradient of tree density and green space structure was detected (Fig.4). The density of tree cover increased from rural settlements to urban residences via a wide range of clustered homesteads. Aside from informal settlements, the degree of homestead clustering correlated positively with richness in ornamental and amenity plant species. However, there was a negative relationship between homestead clustering and diversity of native trees.

Neighborhood plant design and planning

Although there was a slight difference in the quality of plant choice and landscape design between clustered and scattered settlements, there were even more disparities within each type than between the two systems. The image below illustrates this point.

In some sites, despite good tree coverage, it appeared that no proper space had been allocated to street trees during the lotting process (Fig 4, right-bottom image). Furthermore, there were irregularities in lot size, unplanned road networking, and almost no provisions for public space within either system. Possible reasons why include differences in the background and skill levels among local landscape planners. In some cases, road networks are of a rudimentary character, too narrow to accommodate even a single car and lack connectedness.

In post-villagization neighborhoods, there was a prevalence of agro-forestry mosaics: a kind of integrated planting system which focused more on food, fuel wood, medicines, lumber, stakes, and shade provision rather than on landscape aesthetics. Indee, having many plant species mixed up in the neighborhood environment is advantageous to people, because of the many problems they are faced with, including variable weather conditions and increased human pressure on land which necessitates intensive use of space on small plots. The dominant tree species was *Eucalyptus maideni,* planted in clumps around houses,

aligned along plot boundaries or, sometimes, interspersed across the property in association with crops.

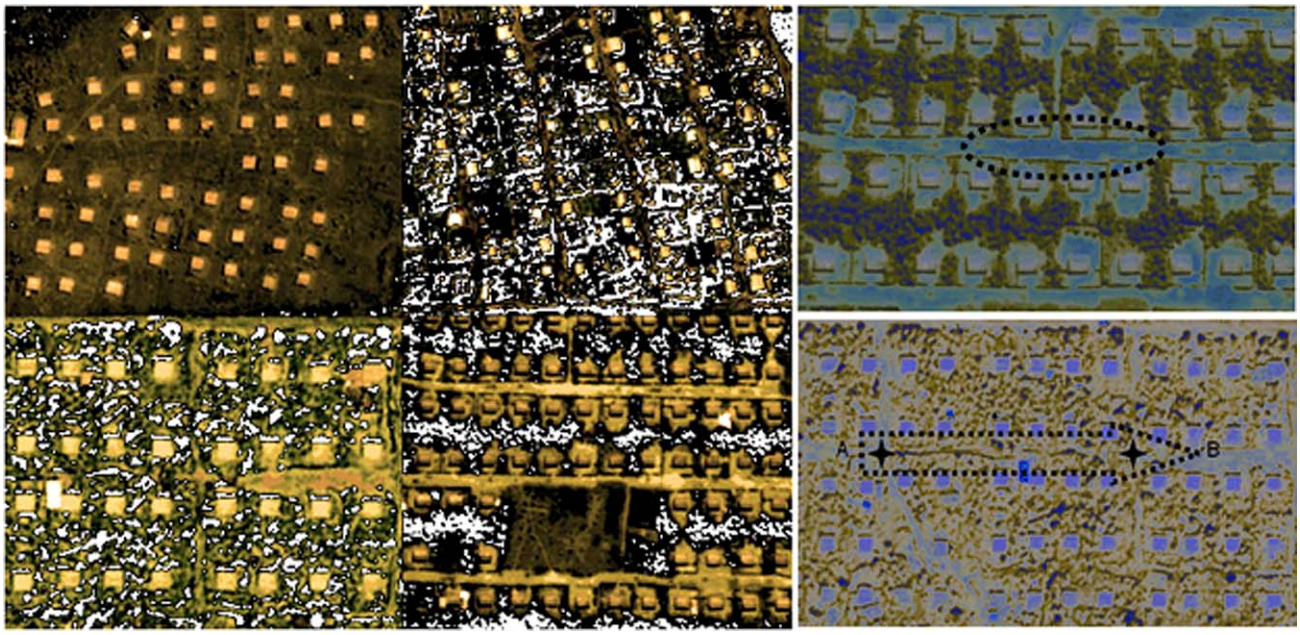

***Fig 4 Post-villagization landscape mosaics in Rwanda's settlement neighborhoods** [Image extracted from Google Earth (2010) and adapted by Author] *The figure comprises three image sets: one on the left (consisting of four sub-images) and two on the right (top and bottom). **(1)** In the left image group, the upper left corner depicts a newly developed settlement site, the least forested and with houses surrounded mostly by bare soil spotted with low vegetation. In the lower right corner lies the best planned neighborhood layout among the four sub-images. The remaining two sub-images illustrate intermediate statuses. In all four sub-images, tree cover appears as white spots while lower layers of plant cover are represented by black-greenish pixels. House roofs, road networks as well as bare soil, are in white-brown. **(2)** The top-right- image depicts the lack of space for street tree planting between roads and lot fences (see inside the black-dashed ellipse). Roads and houses are in light blue, low vegetation is in brown color, and trees are dark blue). **(3)** The bottom-right- image shows poorly planned road network within a cluster settlement: a portion of a road network (extending from a certain point A to B, in a black-dashed arrow), narrow and in poor state, with a line of hedgerow trees which, in reality, is a continuation of lot fencing lines rather than a separate streetscape planting pattern where trees would be regularly planted along alleys. Roads and houses are in light blue-purple, low vegetation in brown, while trees are dark blue.

Landscape mosaics around rural and sub-urban areas

In scattered settlements, the situation was even more revealing. Residences were dispersed along the hillsides and neighborhood tree planting was organized on a family-by-family living basis. Houses were mainly rectangular with members of the nuclear family living together inside a compound-fence surrounded by crop fields spotted by agro-forestry trees. Most of these houses lacked the front part of the compound-fence, contrary to Rwanda's pre-colonial architectural design. The front yard, normally cleared and daily dusted, showed spots of ornamental flowers, shrubs and trees planted on its margins. Among commonly used trees were *Eucalyptus maidenii, Grevillea robusta*, *Cupressus lusitanica, Ficus thonningii* and *Persea americana.*

In particular, around scattered homesteads, either *banana* plantations or, according to socio-ecological context such as soil, climate and human pressure on land, other food crops (including *potatoes, common beans, corn, sorghum* and various vegetables) covered the bulk of available space (see left side of Fig.5). Although the diversity of plant species was higher in scattered settlements, the importance of amenity trees and shrubs was greater near dwellings that are clustered into villages.

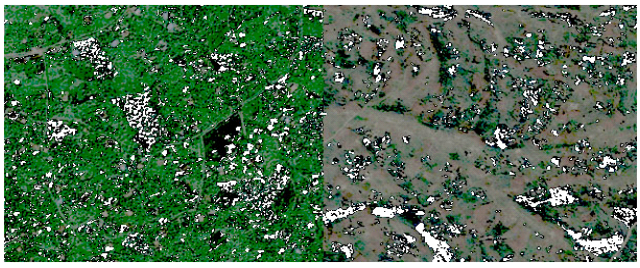

Fig. 5 Neighborhood planting around sub-urban scattered settlements. [Image extracted from Google Earth (2010) and adapted by Author]. Tree cover appears as white spots while lower layers of plant cover are represented by black-greenish pixels. In grey are house roofs, road network as well as bare soil. On the left sub-image, beside housing space, roads and trail networks, the portion of land which is not covered by trees (in white pixels) is mainly occupied by perennial crops such as banana trees while, on the right sub-image, bare soil prevails, depicting a freshly plowed land.

Preservation of potential cultural landscapes

A certain number of potential cultural landscapes, worth putting under a special protection regime, were recognized in this work and; a nation-wide census is under consideration in order to gather more information in this area (Table 1).

Table 1 Potential cultural landscapes and heritage trees in Rwanda. *46 % of interviewees suggest that the heritage tree network should include all trees with a specific cultural value, 31 % wish it includes all trees over a certain age [for example, those aged over 50−70 years], and 23% think it would be better to include those which have reached a certain trunk diameter [at least 50 cm-wide]. The table contains species that belong to these categories.

Landscape Plant Type	Cultural Value	Plant Species to be Preserved	Estimates of Tree Age as of Today	Location of Sites
Spiritual fig, erythrina, spurge and dragon trees.	Worship places: symbols of 'God' awareness among early Rwandans.	*Ficus thonningii* ‘umuvumu' and *Dracaena steudneri* 'igihondo-hondo'	> 100 years	Buhanga relict forest: (Musanze District);
		Euphorbia candelabrum 'umuduha', *Erythrina abyssinica* 'umurinzi'		Neighborhood landscapes: (Burera District); Sites: yet to be identified.
Amenity landscape figs [ibimana, ibiga-biro], erythrines, euphorbes and aca-cias; other species to be identified.	Fingerprints of ancient neighborhood designs and historical burial landscapes; other sites representing specific historical events.	*Ficus thonningii* 'umuvumu', *Erythrina abyssinica* 'umurinzi', *Euphorbia candelabrum* 'umuduha', and *Dracaena steudneri* 'igihondo-hondo'.	Various	Abandoned settlements, ancient graveyards, and traditional settlement neighborhoods (sites yet to be identified).
Street Heritage Trees.	Relicts of colonial and post-colonial landscape designs, models of early native species-based neighborhood designs.	*Polyscias fulva*	> 25 years	RAB gardens, Rubona, Huye District.
		Grevillea robusta	> 50 years	'Plateau' neighborhood: towards KIST, Kigali City.
		Persea americana	> 25 years	Boulevard Umuganda, Kigali City.
			> 25 years	Kigali-Huye roadsides: Ruhango Town.
		Jacaranda mimosifolia	> 50 years	Rwabuye-to-town center, Huye District.
		Spathodea campanulata	> 50 years	Rwabuye-to-town center, Huye District.
		Podocarpus milanjianus	> 25 years	Rwabuye-to-town center, Huye District.
		Eucalyptus spp.	> 75 years	Kigali-Huye roadsides; Rango neighborhood (Huye Town).
		Casuarina equisetifolia	> 50 years	Kigali-Bujumbura roadsides: Muhanga Town.
		Markhamia lutea	± 5 years	Kigali-Bujumbura roadsides: Giticyinyoni (Nyarugenge District).
		Cassia spectabilis	± 5 years	Kigali-Rwamagana roadsides: Ntunga Area.
		Cupressus sempervirens	> 50 years	Towards the Art Museum: Nyanza Town.
		Cedrela serrata	> 25 years	Towards the Art Museum: Nyanza Town.
		Bamboos	>25 years	Kigali-Huye roadsides: Rubona RAB station.
			± 5 years	Kigali-Musanze roadsides: Rulindo District.
		Palms	± 5 years	Main roundabout-to-Kanombe Airport roadside gardens: Kigali City.
Garden, compound fence, plot boundary, windbreak, screen-ing, shade and tradi-tional agro-forestry tree stands.	Cultural villages 'udusozi ndangamurage'. These could be designed to serve as home to families that include elderly people who are willing to share their past experience with the public and entertain with local as well as international tourists and researchers.	*Vernonia amygdalina*, *Cassia didymobotrya*, *Euphorbia tirucalli*, *Ricinus communis*; many other species composing domestic gar-dens, neighborhood tree stands and woodlots as well as agricultural landscapes.	Various (representation of cultural change from one generation to another, and from one place to another). The selection could base on the uniqueness of the Rwandan culture to make the landscapes and com-munities more attractive to visitors.	Sites yet to be identified (the choice of these may base on agro-ecological zones and land use dynamics).

Design-intensive landscape architecture in Rwanda

The rapid expansion of our cities has created the need to address issues of plant planning and design that require the expertise of landscape architects. What follows are some of the most pressing green space architectural and aesthetic concerns that require immediate attention from Rwanda’s urban policy makers. They

can be achieved through informed landscape planning and design work (Table 2).

Table 2. Landscape architectural and aesthetic concerns in urban areas of Rwanda [proposals inspired by Tcpa (2008), Christudason (2005), Liu et al. (1997), and Wong (2004)]

Detected Problem	Area of Improvement	Specific Design Proposals
Dominance of single species (Casuarina trees and plams in Kigali streescapes, *Jacaranda mimosifolia* in Huye District and Duranta shrubs in garden bordering across the country); small share of native species (exotic taxa account for the bulk of neighborhood plant assemblages).	Diversity optimization	Observe a reasonable quota for species nd genera (for example, maximum 5−10% for every single species); 30−40% of the total land cover to be earmarked for green spaces; promote native tree species such as *Polyscias fulva* (refer to RAB gardens, Rubona), *Erythrina abyssinica* (refer to NUR gardens, Ruhande campus), *Hagenia abyssinica* (refer to Gorilla Nest Hotel gardens, Musanze), and *Markhamia lutea* (refer to Giticyinyoni-Ruyenzi roadside gardens, Kigali city).
Disconnection between green space elements (interrupted street tree lines, for example), and lack or insufficiency of public parks in many cities.	Corridor, patch and network definition	Optimization of sizes, structure and shapes of plant assemblages through plant master-planning; consulted work between planners and green space mangers from neighboring municipalities and communities.
Lack of order and too much complexity in many designs, inconsistency in spatial and temporary phenophase combinations and sequences.	Overall beauty enhancement	Stimulation of visual taste by making good use of plant aesthetic attributes such as the variation of flower color and plant shape in space and time.
Disproportional building-garden land allocation; shape and color discrepancies between green and grey infrastructure.	Architectural optimization	Harmonization between plant assemblages and buildings' scales, colors and shapes through consulted work between building designers and landscape architects in regulating ratios of habitable floor space to ground area (plot ratio and development ratio). For example, one-bungalow-per-family housing system should be replaces by multi-story structures to fulfill the housing needs of many while putting land to its most effective use.

Table 2 summarizes the findings of green space structure and aerial image analysis, suggesting inconsistencies in landscape designs, often in positive relationship with socio-economic status and historical background of neighborhoods. Proposed solutions differ among informants: 67% of informants supported that design-intensive landscape architecture appears to be a potential tool of city beautification and environmental sustainability in Rwanda; against 24% who suggested that good management resulting from existing design approaches can yield acceptable results; and 9% said they have no idea of what should be done.

Discussions

Tree cover

Tree cover fraction averaged at around 10%–35% within residential neighborhoods of Kigali city, very close to the results obtained by Singh et al. (2010) in The Netherlands (19%) and Thaiutsa (2008) in Singapore [17.8%], but very low compared to those reported by Jim and Chen (2009) and Zhang et al. (2010) for the far "greener" cities of China (30%–40%). To improve city green infrastructure, we recommend that 40 % of the total land cover be earmarked for green spaces (Town and Country Planning Association 2008). Considering that tree species diversity was found to be low, we further recommend that as future developments are concerned, any species in a street tree population should have a share of not more than 10 % of the total number of specimens in the landscape (Sun 1992).

Dynamics of green space cover

Rwanda's cities have been fast-growing for decades. Using Kigali, Rwanda's capital city, as a model (Fig.1), three major periods can be recognized: a slackening growth between 1900 and 1950, a moderate urbanization rate from 1950 to 1990 and a sharp rise between 1990 and 2010. Although this aspect was not specifically addressed in this study, it can be inferred that there exists a strong relationship between Kigali city population-area model (Fig. 6, lower corner) and trends of green space composition and coverage around the city. During this study, only the analysis of recent landscape mosaic patterning was carried out [using photogrammetric and pixel segregation techniques], which allowed the discrimination of the coverage area of neighborhood plant communities from other land uses (Fig. 6, upper corner).

Fig.1 illustrates the population-area trend for Kigali. Only covering an area of 112 km^2 with 140,000 inhabitants in 1991, the city was believed to have a population of about 1,000,000 people living in an area of 730 km^2 in 2006. Note that, fortunately, the population growth rate, estimated at 600% in 15 years, is roughly equal to the rate of city area expansion, which suggests that any concerns about green space coverage should focus more on possible shifts in the culture of land use planning, design, and implementation within city boundaries rather than on past demographic trends. While ornamental and amenity planting hardly reached 0.5% of Kigali land cover in 2002, much of the city green space coverage went to forested and swampy areas, which, respectively, represented 15.78% and 20.77% of total city

land cover (City of Kigali, 2002). Fig. 6 (lower corner) gives a linear model that can be useful to predict the size of Kigali for a hypothetical population size (Y=6.84X-283862; where X is population size and Y, the city area); Fig. 6 (upper corner): Aerial photo-based analysis of green space cover in three residential neighborhoods of Kigali (arranged in a decreasing order of standard and density: 1_green, 2_semi-green and 3_spontaneous); note that photogrammetric results suggest green space cover estimates of 33.7%, 23.3% and 17.6% respectively for sites 1, 2 and 3.

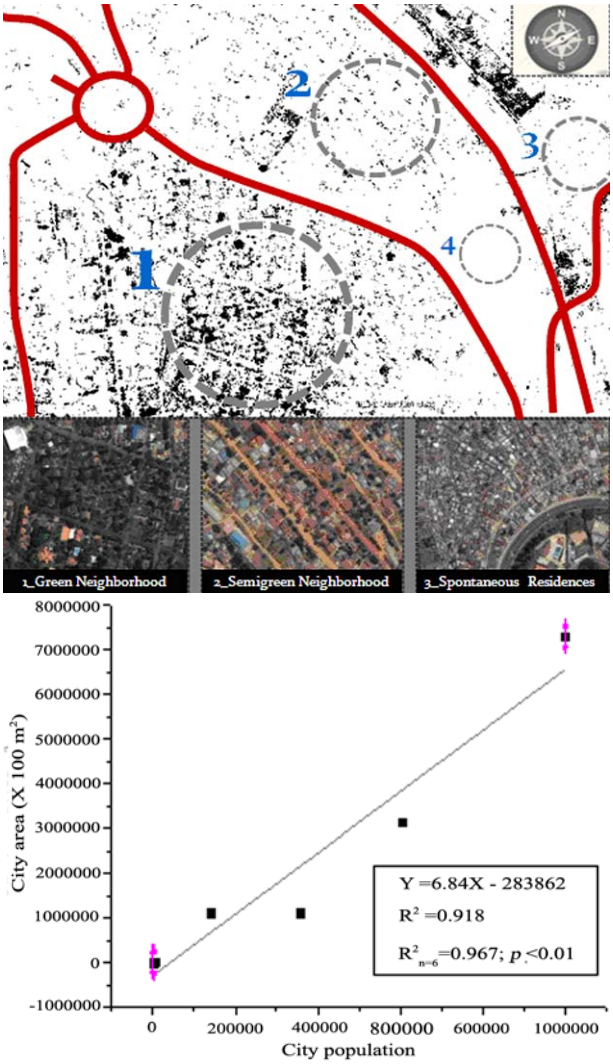

Fig. 6 Population-area trend and green space density in Kigali [Chart constructed using quantitative data from Sano (2007) and Imagery © 2010 Google Inc.]

It follows that, as Kigali becomes one of the most livable urban centers in Africa; the need to develop a network of city green spaces that will enhance its beauty and sustainability while keeping up with its economic growth, is compelling (Mininfra, 2007). Although we lacked such systematic records on population growth and city area trends for other Rwanda urban centers over the same period of time, it can be assumed that they also grew at comparable rates. On the other hand, records on forest plantation area (1960-2002) give an indirect picture of evolving public awareness of tree plantations in Rwanda, which grew at a sharp rate from 1980 through the 1990s (Fig. 2) (Ndayambaje & Mohren 2011). A similar trend was drawn by Seburanga et al. (unpublished) in terms of the dynamics of Rwanda's ornamental tree species richness: the majority of exotic taxa having crossed the border into the country no earlier than the third quarter of 20th century.

Protection of potential heritage tree stands

As suggested by the majority of informants, the heritage tree network would include all trees with a specific cultural value. However, given the low number of potential trees countrywide in spite of ongoing rapid and generalized landscape transformations, even trees over a certain critical age [for example, those aged over 50−70 years] as well as those that have reached a certain threshold value of trunk diameter [at least 50 cm-wide] can be considered for preservation (Fig 7).

For the time being, the focus should be on categories of trees, not on individual trees. Later on, one can shift from such an inclusive approach to identify individual trees that are worthy of long-term preservation. These should then be described, marked, and given legal protection.

Design-intensive models: Multi-story and soft-fence structures

In the context of rapid urbanization on scarce land, like in Singapore and China (Liu et al. 1997; Wong 2004), expansion of green spaces in Rwanda can be achieved by increasing ratios of habitable floor space to ground area by trading-off between single story and hard-gated housing systems, and multi-story and soft-fenced building structures. Indeed, once skillfully designed, the kind of urban landscapes that make good use of natural processes to meet human needs [and with as low inputs as possible] would be way of promoting sustainable green infrastructure and achieving the target of more livable cities in Rwanda.

Socio-economics of plant diversity around the areas of study−the "luxury effect"

In line with Hope et al. (2003) amenity plant diversity was found to be driven by socioeconomic factors. Indeed, there exists a gradient of amenity plant diversity and green space density, along which different levels of human-built plant communities alternate with non-landscaped spaces. Very showy ornamentals and non-productive amenity plants tend to occur more in wealthier neighborhoods in the inner core of cities and towns, while edible ornamentals and other productive neighborhood plant species prevail in spontaneous settlements and other less fortunate areas. Interestingly, it was noted that even within a single neighborhood, the diversity and abundance of ornamentals increased with the socio-economic status of occupants, which corroborates the findings of Yang et al. (2010) suggesting that a correlation does exist between plant diversity and human

demand.

***Fig. 7 Samples of potential heritage tree stands**

***[1]** Fig 7 (top left): Long-standing Australian Eucalyptus trees in Rango (Huye) roadside planting; the trees are potential heritage trees because of their size (60-100 cm DBH) and age (50-80 years old); few are exotic tree specimens of this range of age and girth circumference. Due to ongoing landscape transformations in the wake of rapid urbanization, such wide and old exotic, especially eucalypts are strongly criticized and likely to decrease significantly (Note, however, that, unexpectedly *Eucalyptus camaldulensis*, in Thailand, due to high growth and yield rate, showed larger benefits in the form of carbon sequestration than the native tree *Tectona grandis* (Niskanen, 1998). More recently, in Ethiopia, Alem et al. (2010), found that *E. grandis* plantations improved soil nutrients and sequestered more carbon better than the adjacent submontane rain forest). Preserving these eucalypt trees is needed until a line is drawn about whether eucalypts really cause serious environmental damage in Rwanda. Even in such a case, conserving a certain number of well-selected eucalyptus trees a heritage can still be considered. **[2]** Top right: Mediterranean-native Cypress trees in Nyanza roadside planting. **[3]** Bottom left: Mexican-native ornamental avocadoes in Ruhango roadside planting; still observable in some cities and along intercity highways, and common in streetscapes since the colonial period late 20th century. As Balasubramanian & Egli (1986) put it "the Rwandan farmers, faced with a perpetual land shortage, have evolved certain intensive systems of organic agriculture, involving the combination of food, fodder, and tree crops," here added the "aesthetic perspective." In another study, Ndayambaje et al. (2012) found that fruit tree species, including avocado (*Persea americana*), proved to be among the most planted tree species on farms. If preserved, these tree stands can serve to future generations as symbols of productive landscape design (Lovell 2010; Konijnendijk et al. 2004). **[4]** Bottom right: Polycias trees along an unclassified in-property road in Huye District; this species is Rwandan native and has an important cultural value due to its soft wood with high quality of acoustic resonance (Bloesch et al. 2009). However, despite their potential for such uses, these trees are seldom used in roadside planting, at least not along main arteries; preservation of the above-illustrated population is needed for it can serve as a model for native streetscape designs.

Conclusions

An average tree cover fraction of 10%–35% was revealed around Kigali and Musanze settlements. Fig, euphorbe, and dragon trees, and to some extent erythrines were the type of native trees commonly used in the compound fencing. *Eucalyptus* spp., *Bougainvillea glabra, Grevillea robusta, Cupressus lusitanica* and a number of fruit trees including *Persea americana, Citrus reticulata* and *Psidium guajava* were the most frequent exotic woody species, mainly planted in front of the front compound-fence or as intercrops along with food-oriented resources such as *banana, corn, sorghum* and *potato*. A gradient of green space coverage was detected. The density of tree cover increased from rural settlements to urban residences via a wide range of clustered homesteads. In general, there was higher degree of homestead clustering, richer ornamental and amenity plant species, and fewer native trees. When poverty is not a major constraint, the lack of professionalism in landscape architecture still stand against the development of urban green space layouts that reflect advances in infrastructure planning, design, and construction. For example, despite their relative aesthetic attributes, landscapes lacked originality as, in most cases, the character of the space appeared to be exotic than African-inspired.

On the whole, the need to promote landscape architecture practice in Rwanda was recognized. In particular, the urgency to preserve heritage trees and cultural landscapes in Rwanda's urban areas was discussed. The study recommends that beautifying the urban landscapes and providing well-designed recreational spaces be among the core aims in Rwanda's urban developments.

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